Future Offshore Dynamic Testing Requirements

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Outline

- Background
- Deepwater Technical Issues
- Testing Options
- Possible Deepwater Hybrid Test Stand
- Benefits

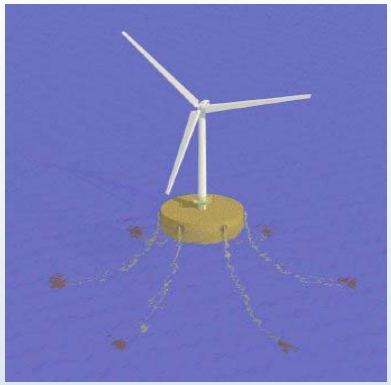
Background

- Testing (verification) is a part of all “innovative marine structures” and all wind turbine development success.
- All “innovative marine structures” must be evaluated by the Coast Guard (delegated to ABS)
- Scaled testing of any floating turbine platform would be prudent, and perhaps required by a third party evaluator.
- A “Design Basis” must be developed for deepwater turbines to reduce risk for commercial investment. This typically includes:
  - Standards
  - Validated engineering models
  - Engineering specifications
  - Scaled and hybrid testing
- Strong design basis will provide tools needed for design innovation and cost reduction.

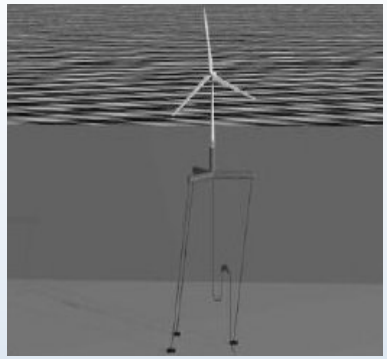
Floating Offshore Turbine Research

Deep Water Platform Concepts

Spar Buoy

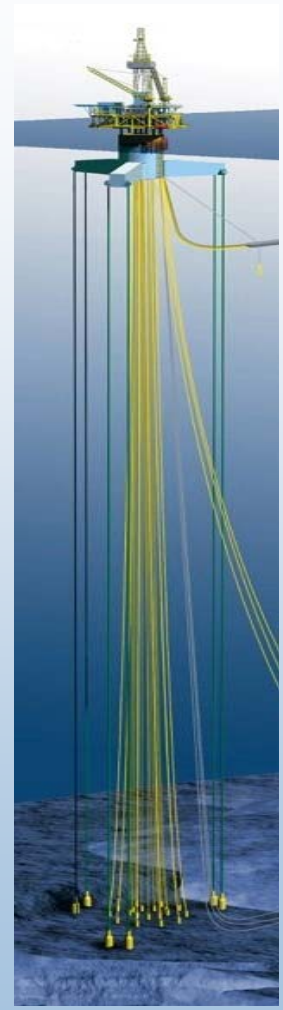


Disk Buoy with Catenary Moorings



Tension Leg Platform

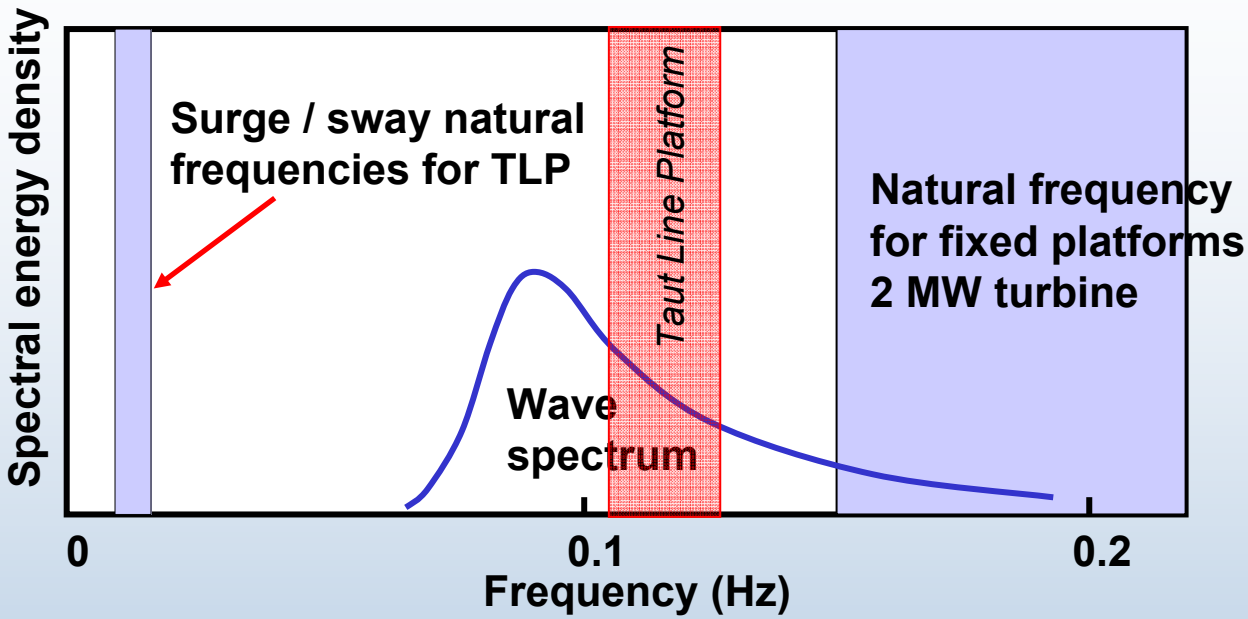
Tri Floater



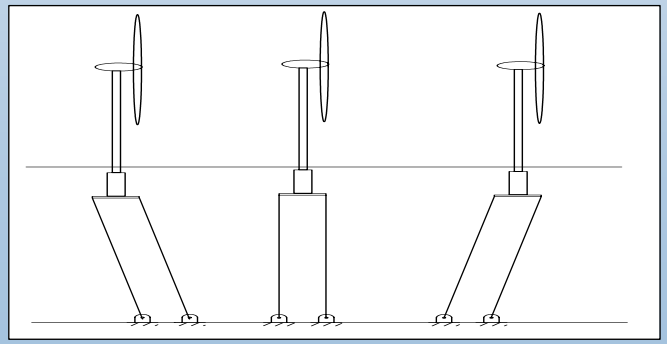
Oil Rig TLP

- Wide range of platform configurations possible
- Each presents very different dynamic & hydrodynamic characteristics
- Modeling requirements challenging
- Verification options limited

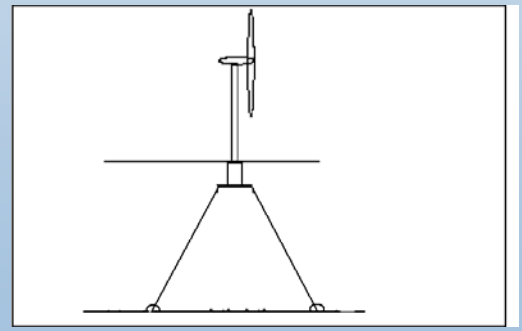
Natural Frequencies and External Conditions



Oil industry example: from John Heidemann, Exxon Mobil



Surge Mode of TLP



Taut Line Platform

Offshore Technical Issues (a partial list)

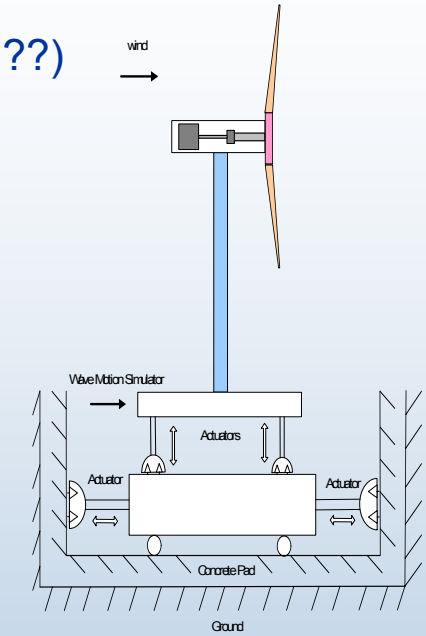
- Wave loading model verification
- Dynamic coupling of wind/wave loads
- Line loading dynamics
- Foundation/anchor dynamic loading
- Model validation
- Control optimization
- What platform/turbine/anchor configuration will offer the most stable / economical compromise?

Prototype Ocean Testing Objectives
(another partial list)

- Technical feasibility (did the hardware survive?)
- Wave loading model verification (can we predict the long term wave – fatigue and extreme - loading using current design tools)
- Methodology for applying simultaneous wind & wave spectra
- Foundation/anchor dynamic loading
- Dynamic simulation model validation
- Control optimization

What Scale Should be Tested?

- Wind / Wave facility scaled model testing? (wind/wave scaling??)
- Hybrid - simulated hydrodynamics / full scale wind turbine?
- Full scale atmospheric testing in open ocean? (cost, test configuration flexibility, risk??)

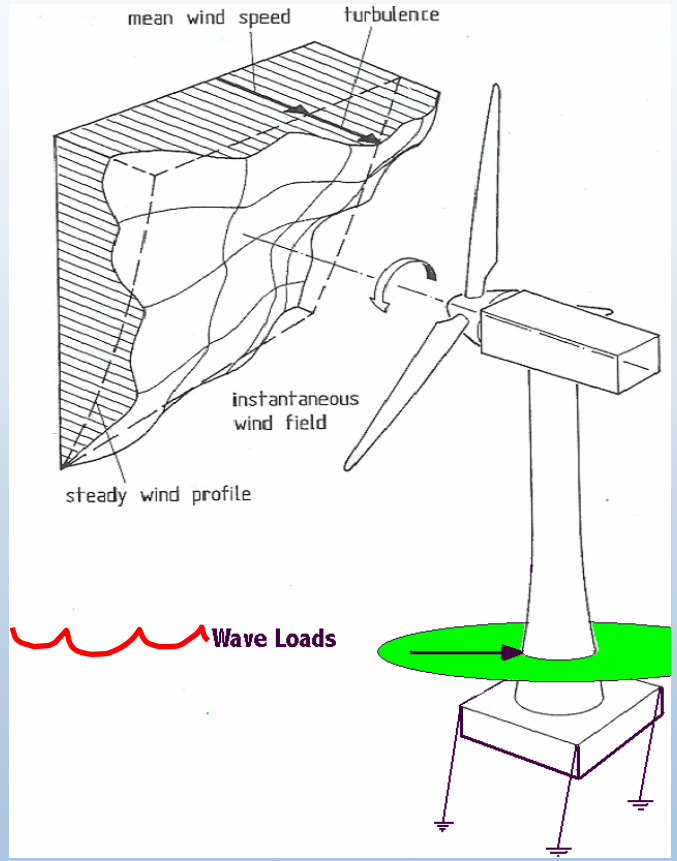


Hybrid Simulator

"Easier to simulate hydrodynamics of platform than turbulence loading"
(Rick Mercier, OTC)

- Scaled turbine (10m)
- Real turbulence loading
- Simulated wave, hydrodynamic, mooring line, platform inertia forces (scaled to rotor dynamics)

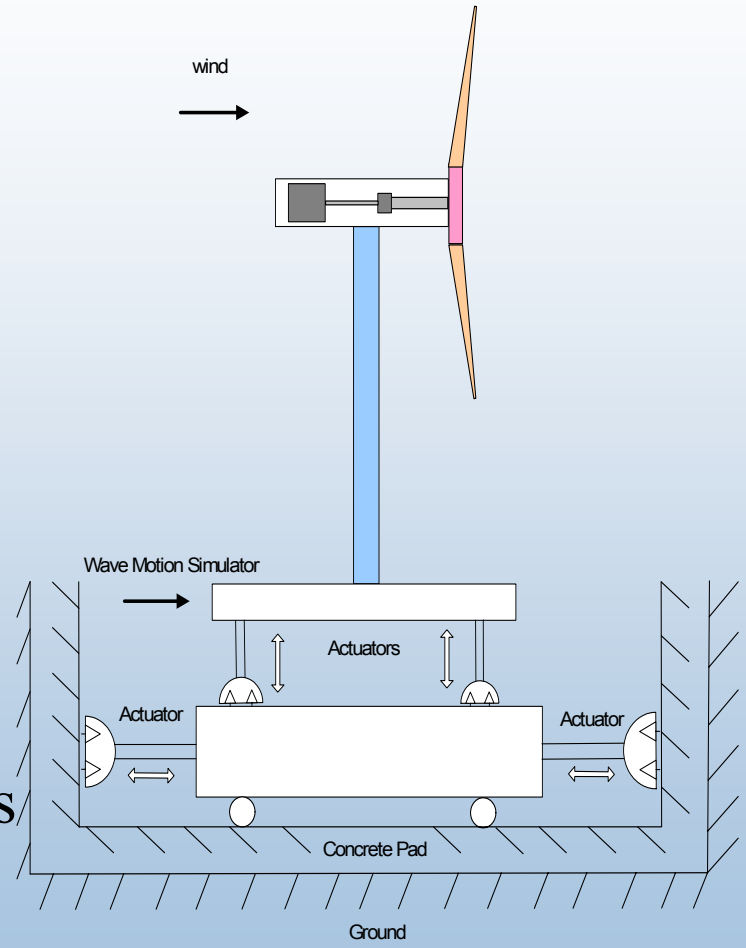
Boeing 747 Flight Simulator



Deepwater Hybrid Platform Simulator

One Possible Facility: Deepwater Hybrid Platform Simulator

- Existing Variable Speed Test Turbine
  - 10m rotor
  - Rotor reconfigurable
  - Variable speed
  - Inexpensive blades
- Platform motion controlled by hydraulic cylinders to simulate wave/hydrodynamic/mooring line equations of motions
- Simulate different platforms/moorings systems through different control algorithms
- NWTC test site?



Approach

- If economics of floating platforms appear promising initiate a conceptual design study to evaluate the cost & benefits of various testing strategies.
- Develop detailed design (FY 2006)
- Construct and commission test facility (FY2007)
- Phase I Tests (FY 2008)
- Coordinate with subcontractors for Phase II hybrid ocean tests?

Benefits

- Validated design tools for accurate prediction of dynamic behavior and loads
- Enable simulation of extreme wave / extreme gust loading.
- Enable simulation of a broad range of platform configurations
- Enable development of stabilizing control systems